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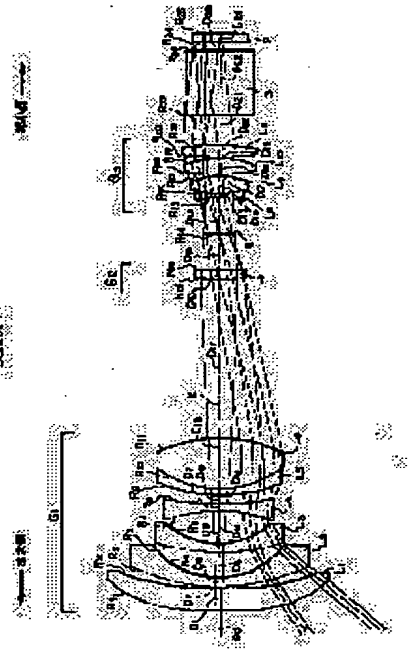
(54) WIDE ANGLE PROJECTING LENS AND PROJECTION TYPE IMAGE DISPLAY DEVICE USING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a wide angle projecting lens capable or highly accurately correcting, especially, distortion and chromatic difference of magnification, and capable of attaining the miniaturization of a liquid crystal rear projection type image display device, and to provide a projection type image display device using the wide angle projecting lens and which is suitable for a multi-display unit by constituting the lens of three groups of negative, positive and positive groups in this order from a magnification side and satisfying a prescribed lens constitution and conditional expressions.

SOLUTION: The lens is constituted by arranging the 1st lens group G1 including a pair of doublets and having a negative power as a whole, the 2nd lens group G2 including one positive lens and having a positive power as a whole, a diaphragm 4, and the 3rd lens group G3 including a pair of doublets and having a positive power as a whole in this order from the magnification side, and the lens satisfies the conditional expressions (1) $-7.5<F1/F<-2.5$, (2) $5.0<F2/F<9.5$, (3) $3.0<F3/F<4.8$ and (4) $2.8<F3/Y<4.5$ provided that F denotes the focal distance of the whole system, Fi denotes the focal distance of an i-th group lens Gi, and Y denotes the maximum image height. The luminous flux carrying image information projected on the display part of a liquid crystal display panel 2 is magnified and projected in the left direction of the paper surface by the wide angle projecting lens through a glass block 3.



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CLAIMS

[Claim(s)]
[Claim 1] The 1st lens group which consists of two or more lenses which contain the cemented lens of the lot which comes to join a forward negative lens sequentially from an expansion side, and has negative refractive power as a whole, The 2nd lens group which has forward refractive power as a whole including at least one positive lens, The wide angle projection lens characterized by arranging the 3rd lens group which consists of drawing and two or more lenses containing the cemented lens of the lot which comes to join a forward negative lens, and has forward refractive power as a whole, and satisfying following conditional-expression (1) - (4).
$-7.5<F1/F<-2.5$ .... (1)
$5.0<F2/F<9.5$ .... (2)
$3.0<F3/F<4.8$ .... (3)
$2.8<F3/Y<4.5$ .... (4)
The focal distance Y of the focal-distance F3:lens [3rd] group of the focal-distance F2:lens [2nd] group of the focal-distance F1:lens [1st] group which is F:whole system here: The maximum image quantity [claim 2] The lens by the side of expansion is a wide angle projection lens according to claim 1 which is used as the aspheric lens of said 1st lens group with which the aspheric surface was most formed in one [at least] field, and is characterized by changing axial top-face spacing with the 2nd lens, and amending fluctuation of the distortion aberration and the image surface accompanying projection distance fluctuation from a this aspheric lens and expansion side.
[Claim 3] The wide angle projection lens according to claim 1 or 2 characterized by arranging the lens with the main biggest thickness among the whole systems into said 1st lens group.
[Claim 4] Said lens with the main biggest thickness is a wide angle projection lens according to claim 3 characterized by being used as a positive lens of the cemented lens in said 1st lens group, and satisfying at least one of the following conditional expression (5) and (6).
$NP1<1.620$ .... (5)
$5.0<FAD/F<6.0$ .... (6)
here -- the inside of the NP1:whole system -- the focal distance [claim 5] of the cemented lens in the refractive-index FAD:1st lens group of a lens with the main biggest thickness It is a wide angle projection lens given in any 1 term among claims 1-3 characterized by arranging the lens equipped with the field where curvature is the smallest among the whole systems into said 2nd lens group.
[Claim 6] claim 1- characterized by the positive lens contained in said 2nd lens group satisfying the following conditional expression (7) -- the inside of 3 and 5 --- a wide angle projection lens given in any 1 term.
$nuP2<30$ .... (7)
The Abbe number of the positive lens contained in the nuP2:2nd lens group here [claim 7] It is [claims 1-3 characterized by the cemented lens contained in said 3rd lens group satisfying the following conditional expression (8), and] a wide angle projection lens given in any 1 term among 5-6.
$40<nuP3-nuN3$ .... (8)
It is the Abbe number [claim 8] of a negative lens among the cemented lenses contained in the Abbe

number nuN3:3rd lens group of a positive lens among the cemented lenses contained in the nuP3:3rd lens group here. The projection mold image display device characterized by the light source, the light valve, and having a wide angle projection lens given in any 1 term, and a screen among claims 1–7.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the projection mold image display device using wide angle projection lens and this especially about the projection lens of the projection mold image display device which carries out expansion projection of the display images on a small display device, such as a liquid crystal display component and a digital micro mirror component (DMD).
[0002]
[Description of the Prior Art] The equipment of the rear method which carries out image formation of the light by which is arranged so that equipment, and the projection lens and appreciation person of the frontal system which carries out image formation of the light by which a projection lens is arranged to a screen at the same side as an appreciation person, and outgoing radiation is carried out from a projection lens to the screen of a reflective mold may insert a screen, and outgoing radiation is carried out from a projection lens to the screen of a transparency mold as a projection mold image display device is known. Among these, a rear–type projection mold image display device dedicates from the light source to a screen to a cabinet, and the configuration projected from the projection lens arranged on the tooth back towards the screen arranged in the front of the cabinet is known well.
[0003] Drawing 6 is drawing showing the fundamental configuration of a rear–type projection mold image display device, and is the vertical cross section which looked at this equipment from the longitudinal direction. This equipment is the liquid crystal video projector which carries out expansion projection of the image on a liquid crystal display component, the abbreviation parallel flux of light from the light source 15 is irradiated by each dot of the liquid crystal display panel 12, and the flux of light which supported the image information which this liquid crystal display panel 12 projected is projected on the rear face of the screen 16 arranged on a predetermined distance with the projection lens 11. An appreciation person will look at the image by which expansion projection was carried out to the screen 16 from the front–face side (space left–hand side) of this screen 16. In addition, although only one liquid crystal display panel 12 is indicated to this liquid crystal projector in order to avoid **** of drawing, generally the color separation optical system which consists of a dichroic mirror and a lens array separates the flux of light from the light source 15 into the three–primary–colors light of R, G, and B, three liquid crystal display panels 12 are arranged in each primary lights, and it considers as the equipment which can display a full color image. This three–primary–colors light is compoundable by arranging a dichroic prism in the location of a glass block 13.
[0004] In the projection mold image display device of such a cabinet type, it is requested that the

volume of the whole equipment is made small from before. Some which were indicated by JP,8-201688,A are one of those are going to meet such a request, for example. In order to make the volume of the whole equipment small, the thing of projection distance, i.e., a projection lens, for which distance from the field by the side of a screen to a screen is shortened most is important, and wide angle-ization of a projection lens is called for. By bending also in this conventional example in the system of wide-angle-izing (a half-field angle is about 41 degrees) of a lens, or a projection lens, and arranging a mirror, it is going to make the volume of the whole equipment small. However, since the increase of weight of equipment will become if it bends in a lens system and a mirror is arranged, it will be more desirable if the volume of equipment can be made small, without being such. Also for that reason, the projection lens [still wide angle / example / this / conventional / for the further space-saving-izing] is called for strongly again.

[0005] Moreover, in recent years, the method of presentation which aligns two or more sets of projection optical units vertically and horizontally, and displays a big screen and which is called a multi-display is also adopted frequently. In this case, in the rear-type projection mold image display device used, when it becomes a big screen, the projection lens with which distortion aberration was amended by altitude is demanded so that the joint part for every unit may not be conspicuous. Specifically, extent is desired less than 0.3%. Moreover, since it is the cause by which it spoils the grace of a screen also about the chromatic aberration of magnification, it must eliminate as much as possible.

[0006] However, in the projection lens, since a contraction side is required to be a tele cent rucksack, it is supposed that the wide-angle-izing itself is difficult, as called a wide angle with extent exceeding 40 half-field angles. It is not easy to amend distortion aberration and the chromatic aberration of magnification moreover. Generally, although, as for the configuration of a wide angle lens, symmetric property has collapsed remarkably by the pre-group and the back group on both sides of the diaphragm, especially this makes difficult amendment of distortion aberration or the chromatic aberration of magnification. Moreover, the demand of tele cent rucksack nature makes aberration amendment still more difficult.

[0007] This invention is made in view of such a situation, and although it is a wide angle lens, it aims at offering the wide angle projection lens which amended distortion aberration and the chromatic aberration of magnification to altitude. Moreover, this invention aims at offering the projection mold image display device which used the above-mentioned wide angle projection lens.

[0008]

[Means for Solving the Problem] The 1st lens group which the wide angle projection lens of this invention consists of two or more lenses which contain the cemented lens of the lot which comes to join a forward negative lens sequentially from an expansion side, and has negative refractive power as a whole, The 2nd lens group which has forward refractive power as a whole including at least one positive lens, The 3rd lens group which consists of drawing and two or more lenses containing the cemented lens of the lot which comes to join a forward negative lens, and has forward refractive power as a whole is arranged, and it is characterized by satisfying following conditional-expression (1) - (4).

[0009]

$-7.5<F1/F<-2.5$ .... (1)

$5.0<F2/F<9.5$ .... (2)

$3.0<F3/F<4.8$ .... (3)

$2.8<F3/Y<4.5$ .... (4)

The focal distance Y of the focal-distance F3:lens [3rd] group of the focal-distance F2:lens [2nd] group of the focal-distance F1:lens [1st] group which is F:whole system here: The maximum image quantity [0010] Moreover, as for the lens by the side of expansion, it is most desirable to consider as the aspheric lens of said 1st lens group with which the aspheric surface was formed in one [at least] field, to change axial top-face spacing with the 2nd lens, and to amend fluctuation of the distortion aberration and the image surface accompanying projection distance fluctuation from a this aspheric lens

and expansion side.
[0011] Moreover, it is desirable that the lens with the main biggest thickness is arranged among the whole systems into said 1st lens group. Moreover, it is more desirable for said lens with the main biggest thickness to be used as a positive lens of the cemented lens in said 1st lens group, and to satisfy at least one of the following conditional expression (5) and (6).
[0012]
NP 1< 1.620 .... (5)
5.0<FAD/F<6.0 .... (6)
Here, while it is the NP1:whole system, it is the focal distance [0013] of the cemented lens in the refractive-index FAD:1st lens group of a lens with the main biggest thickness. Moreover, it is desirable that the lens equipped with the field where curvature is the smallest among the whole systems into said 2nd lens group is arranged. Moreover, it is desirable that the positive lens contained in said 2nd lens group satisfies the following conditional expression (7).
nuP2<30 .... (7)
The Abbe number of the positive lens contained in the nuP2:2nd lens group here [0014] Moreover, it is desirable that the cemented lens contained in said 3rd lens group satisfies the following conditional expression (8).
40<nuP3-nuN3 .... (8)
It is the Abbe number [0015] of a negative lens among the cemented lenses contained in the Abbe number nuN3:3rd lens group of a positive lens among the cemented lenses contained in the nuP3:3rd lens group here. The projection mold image display device of this invention is characterized by having the light source, a light valve, the above-mentioned wide angle projection lens, and a screen.
[0016]
[Embodiment of the Invention] Hereafter, the operation gestalt of this invention is explained using a drawing. Drawing 1 is the lens block diagram and optical-path Fig. of an example 1 which show the wide angle projection lens concerning this invention, and are mentioned later. This lens is explained below as a representative of this operation gestalt.
[0017] This lens namely, sequentially from an expansion side It consists of two or more lenses containing the cemented lens of the lot which comes to join a forward negative lens. As a whole The 1st lens group G1 which has negative refractive power, and at least one positive lens are included. As a whole 3rd lens group G3 which consists of a 2nd lens group G2 which has forward refractive power, diaphragm 4, and two or more lenses containing the cemented lens of the lot which comes to join a forward negative lens, and has forward refractive power as a whole is arranged. Expansion projection of the flux of light which supported the image information which incidence was carried out and the display of the liquid crystal display panel 2 projected from space right-hand side is carried out with this wide angle projection lens through the glass block 3 equivalent to cross prism etc. in the space left lateral. Moreover, the inside X of drawing expresses the optical axis.
[0018] Here, let the lens by the side of expansion (the 1st lens L1) most be the aspheric lens of the 1st lens group G1 with which the aspheric surface was formed in one [at least] field. The configuration of this aspheric surface is prescribed by the aspheric surface type shown below. Although this wide angle projection lens performs a focus by moving an optical-axis top as one, it changes axial top-face spacing with the 2nd lens (the 2nd lens L2), and it consists of this aspheric lens and expansion sides so that fluctuation of the distortion aberration and the image surface accompanying projection distance fluctuation may be amended.
[0019]
[Equation 1]

$$Z = \frac{CY^2}{1 + \sqrt{1 - KC^2Y^2}} + A_4Y^4 + A_6Y^6 + A_8Y^8 + A_{10}Y^{10}$$

ここで、

Z：光軸から高さYの非球面上の点より非球面頂点の接平面（光軸に垂直な平面）に下ろした垂線の長さ

C：非球面の近軸曲率半径Rの逆数

Y：光軸からの高さ

K：離心率

A_4, A_6, A_8, A_{10}：第4, 6, 8, 10次の非球面係数

[0020] Moreover, into the 1st lens group G1, a lens with the main biggest thickness (6th lens L6) is arranged among the whole systems, and this lens is used as a positive lens of the cemented lens in the 1st lens group G1. Moreover, the lens (the 7th lens L7) which curvature is the smallest among the whole systems, namely, was equipped with the field where the absolute value of radius of curvature is the largest into the 2nd lens group G2 is arranged.

[0021] Furthermore, this wide angle projection lens is constituted so that following conditional-expression (1) - (8) may be satisfied.

$-7.5 < F1/F < -2.5$ .... (1)

$5.0 < F2/F < 9.5$ .... (2)

$3.0 < F3/F < 4.8$ .... (3)

$2.8 < F3 / Y < 4.5$ .... (4)

$NP\ 1 < 1.620$ .... (5)

$5.0 < FAD/F < 6.0$ .... (6)

$nuP2 < 30$ .... (7)

$40 < nuP3 - nuN3$ .... (8)

Here F: Focal distance Fof the whole system 1: Focal distance Fof 1st lens group G1 2: Focal distance Fof 2nd lens group G2 3: Focal distance FADof 3rd lens group G3 : Focal distance [of the cemented lens in the 1st lens group G1] Y: Maximum image quantity NP1: Among the whole systems, refractive-index nuPof lens with main biggest thickness 2: The Abbe number nuP3 of the positive lens contained in the lens [2nd] group G2: It is the Abbe number [0022] of a negative lens among the cemented lenses contained in Abbe number nuN3:3rd lens group G3 of a positive lens among the cemented lenses contained in 3rd lens group G3. It explains referring to drawing 2 next about the projection mold image display device using the wide angle projection lens concerning this invention. Drawing 2 is the block diagram of the projection mold image display device equipped with the wide angle projection lens of the example 1 mentioned later, and is the vertical cross section which looked at this equipment from the longitudinal direction.

[0023] This projection mold image display device is the liquid crystal video projector which carries out expansion projection of the image on a liquid crystal display component, the abbreviation parallel flux of light from the light source 5 is irradiated by each dot of the liquid crystal display panel 2, and the flux of light which supported the image information which this liquid crystal display panel 2 projected is projected on the rear face of the screen 6 arranged on a predetermined distance with the projection lens 1. An appreciation person will look at the image by which expansion projection was carried out to the screen 6 from the front-face side (space left-hand side) of this screen 6. In addition, although only one liquid crystal display panel 2 is indicated to this liquid crystal projector in order to avoid **** of drawing, generally the color separation optical system which consists of a dichroic mirror and a lens array separates the flux of light from the light source 5 into the three-primary-colors light of R, G, and B, three liquid crystal display panels 2 are arranged in each primary lights, and it considers as the equipment which can display a full color image. A glass block 3 can be used as the dichroic prism which

compounds this three-primary-colors light.
[0024] Hereafter, the operation effectiveness of the projection mold image display device using the wide angle projection lens and this by this operation gestalt is explained. First, the negative 1st lens group G1, the forward 2nd lens group G2, a diaphragm, and forward 3rd lens group G3 are arranged from the expansion side as this wide angle projection lens was mentioned above. By such power allocation, although this lens is a wide angle, a long back focus can be secured, and it also becomes possible to insert the dichroic prism required in order to project a color picture for color composition in the location of a glass block 3.
[0025] Moreover, it becomes possible by [of the 1st lens group G1] making the lens by the side of expansion into the aspheric surface most to amend distortion aberration effectively. Although this aspheric lens can acquire effectiveness even if one of fields is the lenses made into the aspheric surface, it is more desirable that both sides are the lenses made into the aspheric surface. Furthermore, a positive lens with the main largest thickness is arranged on the 1st lens group G1 among the whole systems, and it acts so that the negative PETTSU bar sum produced from the negative refractive power of the 1st lens group G1 may be negated.
[0026] Moreover, the 2nd lens group G2 is bearing the role to which the forward refractive power of 3rd lens group G3 set up appropriately and the negative refractive power of the 1st lens group G1 which bears wide angle-ization are made for the magnitude of a bond and the whole system not to become large in a rather fantastic way well. Also in sensibility having tended to become large, and the lens arranged on this location having produced gap from the design value slightly at the time of manufacture, when it was a lens with not much strong curvature, the engine performance of a projection lens, especially the engine performance in a tangential surface become easy to deteriorate. By arranging the lens equipped with the field where curvature is the smallest among the whole systems into the 2nd lens group G2, the tolerance of the error at the time of projection lens manufacture increases, and manufacturability improves.
[0027] Hereafter, a monograph affair type is described. Conditional expression (1) is a formula which specifies the power of the 1st lens group G1, and if this lower limit is exceeded and the negative power of the 1st lens group G1 becomes small, it cannot secure a suitable back focus. Moreover, if negative power becomes strong so that this upper limit is exceeded, comatic aberration will become large and amendment will become difficult. Conditional expression (2) is a formula which specifies the power of the 2nd lens group G2, if this lower limit is exceeded and the forward power of the 2nd lens group G2 becomes large, comatic aberration will become large too much and it will become difficult to amend it. Moreover, if forward power becomes weak so that this upper limit is exceeded, the outer diameter of the 1st lens group G1 will become large too much, and will become unreal.
[0028] Conditional expression (3) is a formula which specifies the power of 3rd lens group G3, and if this lower limit is exceeded and the forward power of 3rd lens group G3 becomes large, it cannot secure a suitable back focus. Moreover, if this upper limit is exceeded, a lens overall length will become long too much. Conditional expression (4) is a formula which specifies the power of 3rd lens group G3 to the maximum image quantity, if this lower limit is exceeded, the forward refractive power of 3rd lens group G3 will become strong too much, and it will become difficult that it is compatible in the tele cent rucksack nature by the side of contraction and aberration amendment. If this upper limit is exceeded, the overall length of a projection lens will become long too much.
[0029] Conditional expression (5) and (6) are the conventions about a positive lens with the main biggest thickness among the whole systems allotted into the 1st lens group G1 which has negative refractive power, and it is desirable to satisfy at least one side. Conditional expression (5) is a formula which specifies the refractive index of this lens, and if this upper limit is exceeded, the PETTSU bar sum will become large too much by negative, and it will become image surface over. Conditional expression (6) is a formula which specifies the power of the cemented lens to which this lens and negative lens were joined, if this lower limit is exceeded, spherical aberration will become large too much and it will become

difficult to amend it. If this upper limit is exceeded, the PETTSU bar sum will become large too much by negative, and will become image surface over.
[0030] Conditional expression (7) is a formula which specifies the ingredient of the positive lens contained in the 2nd lens group G2, and even if there is one positive lens arranged on the 2nd lens group G2 and there is, it is desirable to satisfy this formula. [two or more] If this upper limit is exceeded, chromatic aberration, especially axial overtone aberration will become exaggerated too much, and amendment will become difficult. Conditional expression (8) is a formula which specifies the ingredient of the cemented lens in 3rd lens group G3, this cemented lens is acting so that the chromatic aberration of magnification and axial overtone aberration may be amended, and if this lower limit is exceeded, the balance of chromatic aberration will collapse.
[0031] Since the wide angle projection lens of this operation gestalt is considered as such a configuration, although it is a wide angle lens, distortion aberration and the chromatic aberration of magnification can be amended to altitude. Therefore, only a part to have been shortened can make the volume small compared with conventional equipment, and, as for the projection mold image display device using this wide angle projection lens, the projection distance of a lens can attain miniaturization of equipment, and lightweight-ization.
[0032] If drawing 2 of the equipment of drawing 6 mentioned above and the projection mold image display device of this operation gestalt is compared, the effectiveness of the miniaturization by this operation gestalt is clear. Here, 810.7mm and magnitude h of the screen 6 of drawing 2 of magnitude h of the screen 16 of drawing 6 are 806.5mm, this difference is the difference of extent produced since the values of the distortion aberration of a projection lens differ, and both can essentially regard it as the equipment of the screen size of the same magnitude. 1046mm and depth (conjugation length) d of the equipment of drawing 2 are 800mm, and according to the projection mold image display device using the wide angle projection lens of this operation gestalt, although depth (conjugation length) d of the equipment of drawing 6 is a wide angle, when distortion aberration and the chromatic aberration of magnification use the lens amended by altitude, it can miniaturize equipment. Moreover, according to this lens, equipment size can be far made effectively smaller than the case where a mirror is arranged, for example into the system of the projection lens of drawing 6 . When arranging a mirror into a lens system, the weight of equipment will increase so much, and according to the wide angle projection lens of this operation gestalt, a mirror cannot be arranged but ** can also obtain compact equipment.
[0033] Moreover, since distortion aberration and the chromatic aberration of magnification are highly amended as mentioned above, also when aligning two or more sets of projection optical units vertically and horizontally as a multi-display and displaying a big screen, the joint part for every unit cannot be conspicuous, and the projection mold image display device using the wide angle projection lens of this operation gestalt can obtain a high definition big screen.
[0034]
[Example] Hereafter, each example is concretely explained using data.
[0035] <Example 1> The wide angle projection lens concerning this example 1 is considered as the **** configuration it is indicated to drawing 1 that mentioned above. The 1st lens group G1 this lens from an expansion side namely, in order To an expansion side, a convex The 1st lens L1 with which it consisted of a meniscus lens of the turned double-sided said curvature, and both sides were made into the aspheric surface, the 2nd lens L2 which consists of a negative meniscus lens which turned the convex to the expansion side, the 3rd lens L3 which consists of a negative meniscus lens which turned the convex to the expansion side, and the field where curvature is large It consists of cemented lenses with 6th lens L6 which consists of the 4th lens L4 which consists of a biconcave lens towards an expansion side and the 5th lens L5 which consists of a negative meniscus lens which turned the convex to the expansion side, and a biconvex lens which turned to the expansion side the field where curvature is large. Let 6th lens L6 be a lens with the main biggest thickness among the whole systems.
[0036] The 2nd lens group G2 is constituted by one of the 7th lens L7 which consists of a positive

meniscus lens which turned the convex to the expansion side, and the field by the side of contraction of this 7th lens L7 is made into the field where curvature is the smallest among the whole systems. 3rd lens group G3 consists of the 11th lens L11 which consists of a body side from the biconvex lens which turned the field curvature is large in a field to a 10th lens [which consists of a cemented lens of the 8th lens L8 which consists of a biconcave lens which turned to the expansion side the field where curvature is large in order, and the 9th lens L9 which consists of a biconvex lens which turned to the contraction side the field where curvature is large, and a biconvex lens which turned to the contraction side the field where curvature is large] L10, and contraction side.

[0037] The refractive index N in radius-of-curvature [of each lens side of this wide angle projection lens] R (mm), the main thickness of each lens and the air spacing D between each lens (axial top-face spacing is called hereafter) (mm), and d line of each lens and the value of Abbe number nu in d line of each lens are shown in the upper case of Table 1. In addition, in Table 1 and the following tables, the figure of the field number on the left-hand side of front Naka expresses the sequence from a body side, and * mark is given to the field made into the aspheric surface. Moreover, in Table 1 and the following tables, the 0th page is equivalent to a screen and the 25th page is equivalent to the screen of a liquid crystal display panel. Each constant K corresponding to each aspheric surface, A4, and the value of A6, A8, and A10 are shown in the lower berth of Table 1. In addition, each of each examples shown in an example 1 and the following is F value =3.0, omega= 46.7 half-field angles, and 800mm of conjugation length, and let them be the wide angle projection lenses corresponding to the projection screen size of 52 molds.

[0038] The value about monograph affair type [of an example 1] (1) - (8) is as being shown in Table 4 mentioned later. As shown in Table 4, above-mentioned conditional-expression (1) - (8) is satisfied altogether.

[0039]

[Table 1]

面		曲率半径(R)	面間隔(D)	屈折率(N)	アッベ数(ν)
	0	∞	592.07		
*	1	256.842	8.00	1.49018	57.8
*	2	256.842	0.60		
	3	60.393	3.50	1.78590	44.2
	4	25.271	9.25		
	5	66.247	3.00	1.83400	37.2
	6	22.532	12.10		
	7	-46.803	2.50	1.78590	44.2
	8	100.989	3.01		
	9	48.807	2.12	1.84666	23.9
	10	31.833	18.00	1.60342	38.0
	11	-42.353	57.42		
	12	48.347	3.00	1.84666	23.9
	13	490.773	13.66		
	14	絞り	13.12		
	15	-18.870	1.35	1.84666	23.9
	16	29.279	6.64	1.48749	70.2
	17	-19.773	0.30		
	18	57.642	6.00	1.48749	70.2
	19	-28.187	0.30		
	20	102.647	4.26	1.68893	31.1
	21	-68.560	11.00		
	22	∞	23.00	1.51633	64.1
	23	∞	2.75		
	24	∞	3.00	1.51633	64.1
	25	∞			

面	K	A_4	A_6	A_8	A_{10}
1	1.79000×10^{-1}	6.86704×10^{-6}	-2.84461×10^{-9}	1.50993×10^{-12}	-1.94000×10^{-16}
2	1.99000×10^{-1}	6.01710×10^{-6}	-3.21297×10^{-9}	9.18780×10^{-13}	-1.67004×10^{-16}

[0040] <Example 2> The wide angle projection lens concerning this example 2 is considered as the same configuration as the lens of an example 1, and abbreviation. Radius-of-curvature [of each lens side of this wide angle projection lens] R (mm), the axial top-face spacing D of each lens (mm), the refractive index N in d line of each lens, and the value of Abbe number nu in d line of each lens are shown in the upper case of Table 2. Each constant K corresponding to each aspheric surface, A4, and the value of A6, A8, and A10 are shown in the lower berth of Table 2. The value about monograph affair type [of an example 2] (1) - (8) is as being shown in Table 4 mentioned later. As shown in Table 4, above-mentioned conditional-expression (1) - (8) is satisfied altogether.

[0041]

[Table 2]

	面	曲率半径(R)	面間隔(D)	屈折率(N)	アッベ数(ν)
	0	∞	593.26		
*	1	395.752	7.99	1.49018	57.8
*	2	395.752	1.26		
	3	56.313	3.91	1.78590	44.2
	4	24.670	9.52		
	5	77.628	3.00	1.83400	37.2
	6	23.242	10.96		
	7	-47.160	2.50	1.78590	44.2
	8	102.510	1.26		
	9	43.166	2.07	1.84666	23.9
	10	28.163	15.22	1.59551	39.2
	11	-52.032	57.69		
	12	46.581	3.44	1.84666	23.9
	13	8472.494	14.84		
	14	絞り	13.50		
	15	-18.550	1.27	1.84666	23.9
	16	29.726	6.30	1.48749	70.2
	17	-19.768	0.56		
	18	56.493	5.99	1.48749	70.2
	19	-27.815	0.79		
	20	106.630	4.27	1.66680	33.1
	21	-71.518	11.61		
	22	∞	23.00	1.51633	64.1
	23	∞	2.75		
	24	∞	3.00	1.51633	64.1
	25	∞			

面	K	A_4	A_6	A_8	A_{10}
1	1.79235×10^{-1}	6.91970×10^{-6}	-2.90711×10^{-9}	1.49780×10^{-12}	-1.91702×10^{-16}
2	1.99248×10^{-1}	6.06743×10^{-6}	-3.17459×10^{-9}	9.24340×10^{-13}	-1.65747×10^{-16}

[0042] <Example 3> The wide angle projection lens concerning this example 3 is considered as the same configuration as the lens of an example 1, and abbreviation. Radius-of-curvature [of each lens side of this wide angle projection lens] R (mm), the axial top-face spacing D of each lens (mm), the refractive index N in d line of each lens, and the value of Abbe number nu in d line of each lens are shown in the upper case of Table 3. Each constant K corresponding to each aspheric surface, A4, and the value of A6, A8, and A10 are shown in the lower berth of Table 3. The value about monograph affair type [of an example 3] (1) - (8) is as being shown in Table 4 mentioned later. As shown in Table 4, above-mentioned conditional-expression (1) - (8) is satisfied altogether.

[0043]

[Table 3]

面	曲率半径(R)	面間隔(D)	屈折率(N)	アッベ数(ν)
0	∞	591.55		
* 1	279.112	7.90	1.49018	57.8
* 2	279.112	1.65		
3	75.178	3.54	1.78590	44.2
4	25.091	9.22		
5	62.401	3.50	1.83400	37.2
6	23.965	11.74		
7	-52.261	3.00	1.77250	49.6
8	109.727	4.68		
9	58.067	2.83	1.84666	23.9
10	36.862	18.01	1.61293	37.0
11	-40.702	55.96		
12	48.468	3.00	1.84666	23.9
13	207.724	11.73		
14	絞り	13.32		
15	-19.513	1.01	1.84666	23.9
16	29.283	6.84	1.48749	70.2
17	-20.093	0.47		
18	62.223	5.46	1.48749	70.2
19	-29.213	0.30		
20	92.477	4.19	1.69895	30.1
21	-63.528	11.32		
22	∞	23.00	1.51633	64.1
23	∞	2.75		
24	∞	3.00	1.51633	64.1
25	∞			

面	K	A_4	A_6	A_8	A_{10}
1	1.79231×10^{-1}	6.85213×10^{-6}	-2.86447×10^{-9}	1.50190×10^{-12}	-1.94563×10^{-16}
2	1.99252×10^{-1}	6.07445×10^{-6}	-3.21560×10^{-9}	9.11092×10^{-13}	-1.70848×10^{-16}

[0044] The focal distance F of the whole system of examples 1–3 and the value corresponding to monograph affair type (1) – (8) are shown in Table 4.

[0045]

[Table 4]

		実施例1	実施例2	実施例3
焦点距離	F	8.3684373	8.3919859	8.3680408
条件式(1)	F_1/F	-4.5	-3.2	-6.0
条件式(2)	F_2/F	7.5	8.8	6.5
条件式(3)	F_3/F	3.9	4.1	3.7
条件式(4)	F_3/Y	3.6	3.9	3.5
条件式(5)	N_{P1}	1.603	1.596	1.613
条件式(6)	F_{AD}/F	5.4	5.7	5.5
条件式(7)	ν_{P2}	23.9	23.9	23.9
条件式(8)	$\nu_{P3}-\nu_{N3}$	46.3	46.3	46.3

[0046] Drawing 3 –5 are the aberration Fig. showing many aberration (spherical aberration, astigmatism, distortion, and chromatic aberration of magnification) of the wide angle projection lens concerning this examples 1–3. In addition, in a spherical–aberration Fig. and astigmatism Fig., the aberration about the wavelength (B) of 455nm, the wavelength (G) of 546.1nm, and the wavelength (R) of 615nm is shown, and a chromatic–aberration–of–magnification Fig. shows aberration with a wavelength [to the wavelength (G) of 546.1nm / of 455nm] (B), and a wavelength (R) of 615nm. Moreover, in the

astigmatism Fig., aberration [as opposed to / as opposed to / in a continuous line / the sagittal (S) image surface / the tangential (T) image surface in a dotted line] is shown, S or T of the 1st character shows the image surface, and, as for the sign, B, G, or R of the 2nd character shows wavelength. In these aberration Figs., omega shows a half-field angle. As shown in drawing 3 -5, the wide angle projection lens concerning this examples 1-3 begins distortion aberration and the chromatic aberration of magnification, and each aberration is amended by altitude and let them be 46.7 half-field angles and a wide angle projection lens.

[0047] In addition, as a wide angle projection lens of this invention, it is not restricted to the thing of the above-mentioned example, and modification of various modes is possible, for example, it is possible to change suitably the radius of curvature R of each lens and the lens spacing (or lens thickness) D. In addition, in the above-mentioned example, although the lens of this invention is used as a projection lens of the equipment using the liquid crystal display panel of a transparency mold, it is also possible for the use mode of the projection lens of this invention not to be restricted to this, and to use as a projection lens of the equipment using other light modulation means using the liquid crystal display panel of a reflective mold, such as a projection lens of equipment or DMD, etc.

[0048]

[Effect of the Invention] As explained above, according to the wide angle projection lens of this invention, especially distortion aberration and the chromatic aberration of magnification can obtain the highly efficient wide angle projection lens amended by altitude by satisfying a predetermined lens configuration and predetermined conditional expression. Moreover, since the projection mold image display device of this invention uses the above-mentioned wide angle projection lens, it can shorten projection distance and can make the volume of the whole equipment small. Furthermore, since distortion aberration and the chromatic aberration of magnification are amended highly, this wide angle projection lens can obtain a projection mold image display device suitable also as a multi-display.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The lens block diagram and optical-path Fig. of a wide angle projection lens concerning an example 1

[Drawing 2] The block diagram of the projection mold image display device using the wide angle projection lens concerning an example 1

[Drawing 3] Many aberration Figs. of the wide angle projection lens concerning an example 1

[Drawing 4] Many aberration Figs. of the wide angle projection lens concerning an example 2

[Drawing 5] Many aberration Figs. of the wide angle projection lens concerning an example 3

[Drawing 6] Drawing showing the fundamental configuration of a rear-type projection mold image display device

[Description of Notations]

G1 – G3 Lens group
L1–L11 Lens
R1–R25 Radius of curvature
D0–D24 Axial top–face spacing
1 11 Projection lens
2 12 Liquid crystal display panel
3 13 Glass block
4 Drawing
5 15 Light source
6 16 Screen
X Optical axis

[Translation done.]